

## Short Notes

# The lizard, *Podarcis lilfordi* (Squamata: Lacertidae) as a seed disperser of the Mediterranean plant, *Phillyrea media* (Oleaceae)

Valentín Pérez-Mellado<sup>1</sup>, Nuria Riera Riera<sup>2</sup>, Anna Perera<sup>1</sup>, Sandra Martín-García<sup>1</sup>

The phenomenon of saurochory (frugivory and seed dispersal by lizards) has been described from many island areas, such as the Caribbean Islands, Canary Islands, Balearic Islands, New Caledonia and New Zealand, as well as from some continental areas (South Africa and Central and South America, see review in Olesen and Valido, 2003). The knowledge of the interactions between frugivores and fruits is an important element for the conservation of endangered plants (Jordano, 2000; Kitamura et al., 2002), and the role of lizards as legitimate seed dispersers is well known in tropical habitats but few data exists as for temperate regions (Traveset, 1998). Herrera (1995) recognizes that seed dispersal by reptiles in Mediterranean ecosystems has not been extensively studied and that, according to the published literature, could be only relevant in insular habitats. Some data are available for *Lacerta lepida* from Iberian Peninsula (Hernández, 1990), *Gallotia galloti* and *Gallotia atlantica* from Canary Islands (Valido and Nogales, 1994) and *Podarcis lilfordi* from Balearic Islands (Sáez and Traveset, 1995; Traveset,

1995; Castilla, 1999; Pérez-Mellado and Traveset, 1999; Pérez-Mellado et al., 2000).

At insular environments, the low diversity of potential dispersers promotes particular interactions between animals and plant species present in the islands (Iverson, 1985). The Balearic lizard, *Podarcis lilfordi* (Squamata, Lacertidae) is an endemic species only present at Cabrera Archipelago and coastal islets of Mallorca and Menorca. It was extinct from the main islands of the archipelago in historic times and in most of the coastal islets it is currently the only terrestrial vertebrate. *P. lilfordi* is omnivorous, consuming a large variety of prey and plant species (Pérez-Mellado and Corti, 1993; Pérez-Mellado and Traveset, 1999).

In this study we examine the consumption and seed dispersal of the vascular plant, *Phillyrea media* by this lizard in the coastal islet of Rey, Port of Mahón (Menorca, Balearic Islands) and the consequences of this foraging behaviour in the natural regeneration of native vegetation of this islet.

The islet of Rey was used, since long time, as a military hospital. During more than 200 years, the natural vegetation of the island was severely modified with the introduction of several plants used for gardening, e.g. *Aloe arborescens*, *Acanthus mollis* or *Freesia refracta*. During the last 20 years, as a consequence of the abandonment by humans, we observed a progressive substitution of these allochthonous

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1 - Department of Animal Biology, Campus Miguel de Unamuno s/n University of Salamanca, 37071-Salamanca, SPAIN

e-mail: [valentin@usal.es](mailto:valentin@usal.es)

2 - Institut Mediterrani d'Estudis Avançats (CSIC-UIB), C/Miquel Marqués n°21, Esporles, Mallorca, Balearic Islands, SPAIN

vegetation by natural shrublands of *Phillyrea media*, *Olea europaea* and *Pistacia lentiscus* as dominant species.

*Phillyrea media* var. *rodriguezii* (Oleaceae) is an endemic variety of Menorca, and one of the main elements of the Mediterranean shrublands (*Aro-Phillyreetum* community) of the island. This plant species is present in most of the Western Mediterranean basin (Bayer et al., 1989). Its fruit is a spherical drupe with normally two seeds. Ripening occurs in Rey island from May to August or September.

On 31 May 1997 we randomly collected 103 ripening fruits from shrubs of *Phillyrea media* where lizards were previously observed eating fruits, as well as a random sample of 91 faeces of *P. lilfordi* from an area of around 5000 m<sup>2</sup> at the central gardens of the abandoned hospital, today covered by a mixture of natural and introduced plant species. We manually separated the seeds from fleshy fruits, drying out the seeds in darkness at room temperature. From lizard faeces we obtained 120 seeds, from which we cleaned and planted 92. Analyses of faecal samples were done under a dissecting binocular microscope, identifying prey to the level of order (except Formicidae). The relative volume of vegetal remains was estimated by eye, spreading each faecal content on a Petri dish.

Seed germination experiments started on 5 June 1997. We decided to carry out the germination experiment in natural conditions, because studies done in favourable conditions of growth chambers can obscure significant differences between treatments (Traveset et al., 2001). For this reason, each seed was placed on a germination pot, isolated and buried at a 1 cm depth, in potting soil (horticultural mixture). Germination pots were then placed in open-air at the southeastern coast of Menorca island. At Port of Mahón, annual average temperature is 16.6°C and 20.7°C during June, while in Sant Lluís observatory, the closest to germination site, annual average was 17.1°C and 21.7°C during June. Average annual rainfall was 644 mm in Mahón port and 616 mm in Sant Lluís (Jansà, 1979).

Thus, the germination site had very similar environmental conditions than those of Rey island. Seeds were considered viable after leave emergence above the substrate. Trials were finished after 180 days. Two times per day germination pots were checked and watered with a diffusor one time per day.

During the fruiting period, the consumption of *P. media* by *P. lilfordi* is very intense. We found 120 seeds in 66 of 91 collected faeces. Fruits of *P. media* were taken by lizards from the ground, as well as directly from shrubs. In this case, lizards employed a bite to the base of the fruit's attachment and a rapid rotatory movement to pull up the fruit from the branch. This movement seems to be a variant of the common "prey-shaking", typical of predatory bouts in lacertid lizards (Desfilis et al., 1993).

The diet of *Podarcis lilfordi* on spring 1997 was formed by few prey items, with ants, small isopods and beetles as the most common arthropod prey (table 1). 72.5% of faeces contained at least one seed of *P. media* ( $\bar{x} = 1.3$  seeds, range 1-5 seeds, per faecal sample). The fruits of *P. media* were very important because 65 of the 66 faeces containing vegetal remains had seeds and pulp of *P. media*, the most common item (Table 1). Pulp and seeds were also dominant by volume ( $\bar{x} = 75.8 \pm 3.6\%$  of the volume of faecal content, range: 10-100%).

Germination of seeds from plants started one month after plantation on 5<sup>th</sup> July 1997, and ingested seeds on 16<sup>th</sup> July, not significantly later (Kolmogorov-Smirnov test,  $D = 0.2903$ ,  $df = 31$ ,  $P > 0.10$ ). At the end of the experiment, only 30 (32.6%) and 40 (38.8%) seeds from faeces and plants, respectively, germinated. The proportion of germinated seeds was statistically similar in both groups ( $\chi^2 = 2.52$ ,  $df = 1$ ,  $P = 0.11$ ).

Dispersal efficiency is related with several factors, including, dispersers' densities, dispersal distance and average per-capita seed dispersal (see, for example, Fialho, 1990). Our results indicate that the Balearic lizard can be considered a legitimate seed disperser of *Phillyrea me-*

**Table 1.** The diet of *Podarcis lilfordi* during the study period at Rey island. N = number of prey items, % = percentage of a given prey item in the diet, P = number of faeces with a given prey item, % P = percentage of faeces with a given prey item.

TAXON	N	%	P	%P
Gastropoda	1	0.518	1	1.098
Isopoda	26	13.47	24	26.37
Diplopoda	4	2.07	4	4.395
Araneae	9	4.66	9	9.89
Dyctioptera	11	5.699	10	10.98
Homoptera	8	4.145	6	6.59
Heteroptera	10	5.181	10	10.98
Lepidoptera	2	1.036	2	2.197
Coleoptera	15	7.772	12	13.186
Formicidae	94	48.70	43	47.25
Hymenoptera	10	5.181	10	10.98
Arthropoda indet.	3	1.554	2	2.197
Vegetal matter			67	73.92
TOTAL	193		91	

*dia* at Rey island, as in Cabrera island (Sáez and Traveset, 1995). According to our study, this lizard did not produce any detectable damage to seeds, that germinated in a similar proportion as seeds from ripening fruits. Passage through the digestive tract of lizards did not enhance germination of *P. media* as seems to be the case for other plant species dispersed by lizards (Traveset, 1998; Varela and Bucher, 2002). Similar results were found by Traveset et al. (2001) in a germination experiment comparing seeds of *Phillyrea* spp. ingested by birds and from fruits. Also in this study, the proportion of germinated seeds never reached 40%.

The role of *P. lilfordi* in the dispersal of *P. media* is enhanced by some factors. First, the density of lizards is very high (Pérez-Mellado, 1989 and unpub. data), increasing the chance of seed consumption. Fruit ripening of *P. media* takes place from September to November in most parts of its distributional range (López González, 2001). But at Rey island we observed an expanded period of ripening, from May to September in most of the years. Thus, the availability of ripening fruits covers a long period of spring and summer, including the driest time of summer characterized by a very low arthropod availability (Pérez-Mellado, 1989; Pérez-

Mellado and Corti, 1993). In addition, fleshy fruits can be also consumed because of their water content (Barquín and Wildpret, 1975). Considering the high proportion of lizards faeces with seeds, we may conclude that the fruits of *P. media* are an important prey item for *P. lilfordi*.

Birds are currently considered efficient long distance seed dispersers (Jordano, 2000). However, according to the so-called Janzen-Connell hypothesis (Janzen, 1970), even the closer seed dispersal made by lizards could be important at small coastal islets enabling seeds to escape the high density-dependent mortality under parent plant (Wang and Smith, 2002).

Dispersal and germination of seeds by the Balearic lizard can be an important interaction of lizards and endemic plants in Balearic Islands (Pérez-Mellado and Traveset, 1999; Rivera et al., 2002). Landscape and vegetation of Rey island were deeply transformed by the long human occupation and, particularly, by the introduction during XVIII and XIX centuries of several cultivated plant species for gardening, threatening the natural vegetation of the island. The abandonment of the hospital allowed the slow recovery of natural vegetation with a progressive substitution of introduced by native plant species. Lacking other suitable terrestrial vertebrates, the dispersal of *P. media* by the Balearic lizards, as well as the seed dispersal of other plant species (Pérez-Mellado, unpub.), could have, as it is widely recognized in other ecosystems (Wang and Smith, 2002), an important role in the regeneration of natural vegetation.

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